Opportunity Costs as a Determinant of Participation in Payments for Ecosystem Service Schemes

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Abstract

Landholders are generally assumed to be willing to participate in payments for ecosystem service (PES) schemes if the offered payment exceeds the opportunity cost of participation. The calculation of opportunity costs is often based on historic financial data such as net returns of the formerly practiced land use. Reliable estimates of opportunity costs are required especially in flexible, cost-aligned payment schemes with differentiated payments at the farm scale. We question whether opportunity cost estimates that do not consider personal landholder characteristics such as risk considerations, information access and non-monetary personal preferences (e.g. for traditional land use practices) are sufficient to explain a landholder‘s decision to enrol land in PES. To test these assumptions, a PES adoption model was developed for hypothetical adoption decisions by 178 landholders in Costa Rica. The model explained up to 73.5% (Nagelkerkes pseudo R^2) of adoption variance. The results confirm that adoption is not determined by financial costs alone. Trust in state institutions, for example, was highly significant. The results call for more integrated methods of opportunity cost estimation such as inverse auctions. Their strength lies, among others, in that all adoption determinants are potentially expressed in the landholder‘s bid.

1 Introduction

Landholders are generally assumed to be willing to participate in payments for ecosystem service (PES) schemes if the offered per hectare payment ($C_{payment}$) exceeds their participation cost (C_i), i.e. the sum of their per hectare opportunity (C_{opp}), conservation (C_c) and transaction costs (C_t). Following the definitions used in Wünscher et al. (2008), opportunity costs refer to the difference in income between the most profitable land use (before PES) and land retirement. Protection costs include all active protection efforts (e.g. firebreaks) and the landholders' transaction costs are all residual PES-related landholder expenses for contract establishment and maintenance (e.g. travel expenses and information gathering). The sum of these three cost elements is defined here as the participation cost. The calculation of opportunity costs is often based on historic financial data such as net returns of the formerly practiced land use. Reliable estimates of opportunity costs are required especially in flexible, cost-aligned payment schemes with differentiated payments at the farm scale. In this paper we question the assumption that historic opportunity cost estimates fully represent all relevant opportunity costs. Rather, a landholder’s opportunity cost is the expected future net return B_{exp} which depends on returns in the past (C_{opp}), perceived risk and risk behavior (R) and the ability to access and process information (I). Also, it is possible that non-monetary costs and benefits (N) influence the landholder’s opportunity cost and adoption decision. For example, professional pride or tradition may increase the perceived personal cost of land retirement. The sum of monetary and non-monetary values can be expressed in utilities. The utility of the agricultural land use option (U_a) could then be expressed in:

$$U_a = U_a (B_{exp}, N_a) \quad (1)$$

where B_{exp} is a function of past returns (C_{opp}), risk perceptions and behavior (R) and information (I):

$$B_{exp} = B_{exp}(C_{opp}, R, I) \quad (2)$$

and N_a are the non-monetary costs and benefits of the agricultural land use option. Synonymously, forest conservation through PES enrollment has a utility (U_c) which depends on the expected net payment (P_{exp}) and non-monetary values of forest conservation (N_c):

$$U_c = U_c (P_{exp}, N_c) \quad (3)$$

where P_{exp} is a function of the offered payment ($C_{payment}$), expected transaction and protection costs (C_{t+p}), perceived risk and risk behavior (R) as well as the ability to access and process information (I):

$$P_{exp} = P_{exp}(C_{payment}, C_{t+p}, R, I) \quad (4)$$

Mistrust towards state-run programs may, for example, increase the perceived risk that the payment ($C_{payment}$) will not be made. The non-monetary benefit from PES participation (N_c) can, for example, be higher if a landholder has a general sympathy towards nature conservation. The decision to enroll land in the PES program would then not depend on a comparison of $C_{payment}$ and C_i but rather on the utilities U_a and U_c:

$$\gamma_i = 1 \quad \text{if} \quad U_a < U_c \; ; \qquad \gamma_i = 0 \text{ otherwise} \tag{5}$$

where $\gamma_i \in \{0,1\}$ is an indicator variable reflecting participation.

While it is difficult to monetarily value risk considerations, information and personal preferences, it is attempted here to study variables that are known or expected to have an influence on these criteria and thus on the landholder's enrolment decision. For example, the perceived risk from implementing a new technology or land use, here the production of environmental services through PES, has been shown to increase with age. The access to information may depend on the distance to commercial centers and on-farm infrastructure; and the ability to interpret and utilize such information can depend on the educational level. The objective is to analyze whether factors other than monetary flows in the past influence enrolment decisions given a flat per hectare payment. These factors have been known and analyzed for many years in so called "adoption" studies for newly developed agricultural technologies (e.g. Albrecht 1969, Mössner 1958, Rogers 1962, von Platen 1985, Gabersek 1990, Zbinden and Lee 2005). Instead of calculating U_a and U_c to determine γ_i, adoption studies seek to explain the adoption ($\gamma_i = 1$) of a new technology (here production of ES) with explanatory variables that also influence the values of U_a and U_c. In the adoption analysis presented here, participation cost is one of the variables that are examined, together with a number of other variables which are believed to proxy participation costs, risk considerations, information and individual preferences. The paper continues in section 2 with an overview of factors known in adoption theory to influence adoption, then lays out the methodology used for the analysis (section 3), subsequently presents and discusses the results (section 4) and concludes with final comments in section (5).

2 Adoption Theory

Adoption can be defined as the taking-over of an innovation by an individual or another "taking-over unit" (Albrecht 1969). Adoption research has its origin in the North American extension service, which wanted to evaluate the success of its work by the rate of adoption of recommended innovations (Mössner 1958). Whether or not adoption takes place is influenced by characteristics of the innovation as well as by characteristics of the farmer himself and of the society which (s)he lives in. Here we focus on the characteristics of the landholder as potential drivers for the adoption of PES. Von Platen (1985) points out the crucial influence the following factors have on adoption:

1. The economic situation: Poorer landholders are less likely to take a risk by trying "new things", which could bring them into economic dependency (from creditors, middlemen, etc.) or could even, in the worst case, endanger their existence. Farm size has often been used as an indicator of the economic situation because it is easily quantifiable. Large farms tend to have higher absolute profits and can therefore more easily introduce capital intensive innovations. However, 33% of all studies of this kind (of 228 in total) came to the conclusion that farm size had no influence on the adoption of innovations.

2. The level of education: The higher the educational standard, the higher is a landholders ability to identify problems and the more likely (s)he is to search for information and solutions beyond the traditional means. Rogers (1962) could prove a positive correlation between education and innovative readiness.

3. The attitude of the society towards innovations: The more reserved a society is towards changes, the less a member of this society will dare to try innovations, because he will run the risk of being excluded from social life.

4. The support (in the form of credit, technical assistance, etc.): The more support the government or other institutions dedicate to the introduction of an innovation and the more assistance the farmer receives in his decision making processes, the more likely the farmer is to adopt the innovation.

5. Social participation and cosmopoliteness: These terms refer to the open-mindedness of a landholder. Both are reflected by indicators such as membership in farming organizations and a generally positive attitude towards extension. The effect is better access to information exchange. A large number of studies found a positive correlation between social participation and the adoption of innovations. Rogers (1983) analyzed 174 publications with regard to cosmopoliteness and found that 74% of these confirmed this correlation.

6. Presence of key persons: If key persons (persons with a strong influence on the opinions of other farmers) adopt an innovation, the confidence of other farmers in the new technology rises and they are more likely to adopt it themselves. The key persons are not necessarily the innovators who – sometimes – are not fully integrated into the society of the majority.

7. Access to information: Adoption theory distinguishes the classes "interpersonal communication" and "mass media communication". The presence of these communication forms can increase the flow of information. More information helps reduce the perception of risk and thus the adoption process is accelerated. Which of the two classes of communication has the stronger influence on adoption differs and may depend on the type of innovation and/or the individual situation and characteristics of a farmer. Mass media are often seen as an instrument to spread first general information among the potential adopter group. In contrast, interpersonal communication can respond to individual problems and questions. However, interpersonal communication holds the risk that that "second hand" and thus less precise information is passed on.

8. Risk aversion: The less risk averse a farmer is the more likely he is to adopt a new technology. Individually perceived risk can be reduced by information supply.

Gabersek (1990) makes clear that it is very difficult to generalize what determines adoption. The factors influencing adoption differ very much from case to case. In this sense, Albrecht (1969) admitted that the insight gained in one case can not be transferred to another. The motives, objectives and opinions of farmers may vary widely from situation to situation. Moreover, there are large discrepancies between verbally expressed opinions and actually realized behavior (Six 1975).

3 Methodology and Variables

A field survey was administered to 178 randomly selected landholders on the Nicoya Peninsula in the Northwest of Costa Rica. The Nicoya Peninsula has a long tradition of beef production and is the region with the largest extension of pasture land (375,400 ha) in Costa Rica (CORFORGA 2001). The survey's objective was to obtain data on hypothetical adoption decisions as well as personal landholder and farm characteristics. The geographical locations of the farms were determined using a global positioning system (GPS) in order to complement the information with secondary spatial data such as soil quality and slope. Table 1 provides an overview of the variables that were derived from the survey including an explanation of their meaning and expected influence on adoption. Two crucial variables ('PES adoption' and 'ParticipationCosts') are discussed here in more detail outside Table 1. In order to obtain information about the adoption behavior of landholders, the Costa Rican PES program in its valid form of 2005 with respect to forest conservation (requirements, obligations, payment levels, etc.) was described in detail to the 178 landholders. The PES program in Costa Rica pays a flat rate of around US$40 per hectare and year for the conservation of forest. It also pays for the establishment of timber plantations and agro-forestry but these were excluded from the description. In addition to the 2005 program conditions, the option to retire agricultural land and allow natural forest regrowth for the same per hectare payment of around US$40 was also described[1]. Following the program description, the interviewees were asked whether under these conditions they would place part of their land in the PES program. Those with an affirmative answer were classified as hypothetical adopters.

Participation costs include opportunity, protection and transaction costs. For the calculation of opportunity costs, 'pastureland' is focused as the most likely alternative to natural forest. Natural forest itself is assumed to produce no commercial income. This is because timber sales from natural

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[1] This option was officially included in the PES program in 2006 with a payment of US$41/ha/year.

forests are prohibited by law, unless a management plan has been certified by Costa Rican authorities, which in recent years has almost never occurred. Illegal timber transport is risky, and very few rule violations seem to occur in the study area. Data of this study's field survey also show that non-timber benefits are close to zero. However, gradual land-use change towards pastures without timber commercialization is somewhat more frequently observed in the Nicoya Peninsula. Thus, the opportunity cost of maintaining forest is equal to the foregone optional net return from pastures. Micro level net returns of pastureland were calculated by subtracting from the sum of incoming monetary flows of a defined reference year (e.g. from sales of cattle, milk, cheese, hay or renting out farm land) the sum of outgoing monetary flows (e.g. through purchase of farm inputs such as fertilizer, seed, herbicide, machinery, petrol). This approach is here referred to as the 'Flow' approach.

The landowners' transaction costs are expenses for contract establishment and maintenance (e.g. travel expenses, information gathering, and external monitoring). On the Nicoya Peninsula, the great majority of PES applications for small and medium sized land plots (<100 ha) is processed by intermediaries (J.A. Jiménez Fajardo, pers. comm., 2007), who handle all associated transactions such as paper work, consultancy, technical study and supervision. For this service, the intermediaries charge a maximum of 18% of the payment, i.e. 7.20US$/ha, which is used as an approximation for transaction costs. Applications for large land plots (>100 ha) are normally processed by private forest engineers who may offer lower per hectare prices. For these land plots a hypothetical transaction cost of 12% of the PES payment is used, i.e. 4.80US$/ha .

Finally, protection costs relate to active forest-protection efforts and mainly consist of establishing firebreaks, fencing off cattle and signposting the areas under PES contracts. Protection costs are estimated for every plot individually based on the survey data. Firebreak costs were taken directly from survey data. Fencing costs were calculated multiplying per ha fencing costs for pasture with the factor 0.1818. Sign posts were estimated at 5 US$ for every 50 hectares. The mean protection cost is 3.56 US$/ha/yr (Min 0.11, Max 23.07, S.D. 3.66).

Two Logit models were constructed to examine the explanatory effect of the variables in Table 1 on the hypothetical adoption decision. The variables for the model are selected with the use of a backward elimination procedure. Since logistic models do not necessarily require normal distribution of determinants, transformations are refrained from.

Table 1 Variables with an expected explanatory effect on adoption

Dependent Variable	**Meaning (expected effect in brackets)**	**Type**	**Exp. sign**
PES Adoption	Hypothetical acceptance of a PES contract under the conditions of the Costa Rican PES program as of 2005. 1 = Yes, I would include part of my land in the program. 0 = No, I would not include part of my land in the program.	binomial	
Independent Variables	**Meaning (Hypothesized effect)**	**type**	
Variables which proxy costs of participation			
ParticipationCosts	Sum of opportunity, transaction and conservation costs. Opportunity costs according to Flow approach. (Higher costs are expected to decrease adoption probability).	metric	(-)
PriceIndex	Index for product prices in %. Constructed from own survey data on product prices. Sample average is 100%. (Higher prices, i.e. higher index values, are expected to increase opportunity costs and hence decrease adoption probability.)	metric	(-)
FactorIndex	Index for factor costs in %. Constructed from own survey data on factor costs. Sample average is 100%. (Higher factor prices, i.e. higher index values are expected to decrease opportunity costs and hence increase adoption probability.)	metric	(+)
DistAuction	Distance in kilometers to nearest cattle auction center. Distance measured "as the crow flies". (Longer distance is expected to increase product transport costs, thus decrease opportunity costs and hence increase adoption probability.)	metric	(+)
DistCommerce	Distance in kilometers to nearest commercial center. Distance measured "as the crow flies". (Longer distance is expected to	metric	(+)

	increase transport costs, thus decrease opportunity costs and hence increase adoption probability.)		
Slope	Average slope of land in %. (Steeper slopes reduce production capacity and are thus expected to decrease opportunity costs and increase adoption probability.)	metric	(+)
Altitude	Altitude in meters above sea level. (Higher elevations with moderate temperatures favor agricultural production and thus increase opportunity costs decreasing adoption probability.)	metric	(-)
Capacity	Soil use capacity for agricultural production. Six categories with decreasing quality from II (best) to VIII (worst) transformed to five dummies with category II used as reference category. Categories from II upwards are expected to decrease opportunity costs and thus increase adoption probability.)	binomial	(+)
FamilyWork	Family members work in farming activities (1) or they do not (0). (Availability of family labor is expected to increase opportunity costs and thus decrease PES adoption probabilities.)	binomial	(-)
ProductionFocus	Main production focus: 0=principally meat, 1=milk and meat, (zero farms produced principally milk). Milk production is generally a more profitable agricultural activity. Therefore the joint production of 'milk and meat' is expected to increase opportunity costs and thus decrease adoption probabilities.)	binomial	(-)
FireBreaks	Fire breaks were given maintenance in 2004 (1) or they were not (0). (Costa Rica's PSA program requires fire breaks. If fire breaks are already maintained they are not perceived to be an additional cost. Adoption probability is therefore expected to increase with 1)	binomial	(+)
Canton	Canton in which land parcel is located (canton is an administrative unit that is smaller than the province but larger than municipality and district). Five dummies for six cantons. Canton Carrillo is reference canton. (The other cantons of the study area, namely Hojancha, Nandayure, Nicoya, Puntarenas, Santa Cruz, are expected to have lower per hectare returns than Carrillo and therefore higher adoption probabilities.	binomial	(+)
Variables which primarily measure or proxy risk considerations			
Area	Size of land property in hectares. Property size is expected to have contrary effects: (1a) A large property allows the land owner to 'experiment' with the new land-use on small parcels without significant risk to the overall enterprise, thus increasing adoption probability. (1b) Area proxies the overall economic situation. The risk of adoption decreases with the economic situation (failure can more easily be buffered) and increases the probability of adoption. (1c) A large property also decreases transaction costs and thus increases adoption probability. (2) Economies of scale (and thus opportunity costs) increase with property size, hence decreasing adoption probability.	metric	(+/-)
Consumption	Household consumption. Four categories for low (1) to high consumption (4) represented by three dummies. Category 1 is used as reference category. (Household consumption is assumed to proxy the economic situation of the landowner. It is expected that the risk of adoption decreases with the economic situation (failure can more easily be buffered) and increases the probability of adoption.	binomial	(+)
Off-farmIncome	Existence of off-farm income: 1=yes, 0=no. (Off-farm income decreases dependence on farm production and thus willingness to take risks with new land use technologies such as PES. As a result, adoption probability increases with off-farm income.)	binomial	(+)
%FarmIncome	Percentage of income that is generated on-farm. (The expectation for this variable follows the argumentation of the variable 'Off-farmIncome'. The risk of adopting new land-use technologies (here PES) increases with on-farm income, hence decreasing adoption probability.)	metric	(-)
Forest	Existence of forest on land property: 1=yes, 0=no. The existence of forest enables the landowner to adopt PES as an 'additive' land use as opposed to a 'substitutive' land use in the presence of pasture	binomial	(+)

	only. Introducing the new technology, here PES, as an 'additive' component reduces the risk and thus increases adoption probability.		
%Forest	Percentage of total property area with forest. (This variable is similar to the previous ('Forest'), yet instead of indicating only the existence of forest it measures its proportion. Higher percentages increase the possibility of 'additive' technology adoption, here PES, which decreases risk and thus increases adoption probability.	metric	(+)
HouseholdSize	Number of household members. (This variable is expected to have two complementary effects on adoption: Household size increases vulnerability and thus the risk aversion of the landowner. Hence, adoption probability decreases. (ii) Household size increases the availability of family labor increasing opportunity costs, and thus decreasing adoption probability.)	count	(-)
Trust	Degree of trust in state-run programs. Three variables low (1), medium (2) and high degree of trust (3) transformed to two dummies variables with category (1) as reference. Higher degrees of trust decrease the perceived risk of adoption and thus increase adoption probability.	binomial	(+)
ProfitExpectations	Land owner's expected profit trends. Returns will go down (1), stay the same or will go up (0). (Expectations for returns to decrease would increase the attractiveness of PES and its adoption probability.)	binomial	(+)
RiskBehavior	Risk behavior. Interviewees were asked to choose between three business opportunities with different levels of risk. Depending on their choice interviewees were classified as risk-averse (1) or other (0). Risk-averse landholders are less likely to adopt a new technology, hence adoption probability is expected to decrease.	binomial	(-)
Age	Age of land owner. (In general older landholders are expected to be more risk averse or conservative decreasing the adoption probability of PES).	metric	(-)
Variables which proxy ability to access and process information			
EducationalLevel	Educational level of farm owner. Five categories from 'never went to school' (0) to 'Higher education' (4). Reference Dummy is category 1. (Higher educational levels are expected to increase the ability to access and process information which decreases uncertainties and hence the perceived risk of adoption. Adoption probability is expected to increase with education.)	binomial	(+/-)
DistInfoCenters	Distance in kilometers from land property to four 'PES information centers' which are: Agricultural Cantonal Centers (i) Hojancha, (ii) Nandayure, (iii) Puntarenas and (iv) non-governmental organization Fundecongo. Increasing distance inhibits access to information on PES which increases the perceived risk of participation and thus decreases adoption probability.		(-)
Road	Type and quality of road leading to property. Categories from 1 to 5 with decreasing quality, transformed to four dummies with reference category 1. (Road type is expected to have two contrary effects: (i) Decreasing road quality reduces the access to information on PES and thus increases the perceived risk, hence decreasing adoption probability. (ii) Decreasing road quality increases transport costs and thus decreases opportunity costs increasing adoption probability.)	binomial	(+/-)
Accessibility	All year accessibility of property with 4x2 automobile. 1=yes, 0=no. (This variable is simplified version of the previous variable 'Road' and thus is also expected to have two contrary effects: (i) All year accessibility improves the access to information about PES and thus decreases the perceived risk, hence increasing adoption probability. (ii) All year accessibility decreases transport costs and thus increases opportunity costs, decreasing adoption probability.)	binomial	(+/-)
Variables which proxy perceived non-monetary costs/benefits			
Conscience	State of conscience in the hypothetical situation of having cut down a tree: 1=bad conscience, 0=other. (Adoption probability is expected to be higher among those with a 'bad conscience' because their perceived personal benefit from cutting a tree is lower than for those	binomial	(+)

	who do not have a bad conscience).		
FearDenounce	Fear to be reported to the police in the hypothetical situation of having cut down a tree: 1=fear, 0=other. (Adoption probability is expected to be higher among those who fear to be reported to the police because their perceived personal benefit from cutting a tree is lower than for those who do not fear to be reported).	binomial	(+)
FearReputation	Fear that one's social reputation could suffer in the hypothetical situation of having cut down a tree: 1=fear, 0=other. (Adoption probability is expected to be higher among those who fear to lose social reputation because their perceived personal benefit from cutting a tree is lower than for those who do not fear to lose reputation).	binomial	(+)
Other variables			
NumberLandlords	Number of property owners. (It is expected that a higher number of owners decreases PES adoption probabilities because among a larger group of decision makers it is more difficult to come to an agreement for land-use change.)	count	(-)

4 Results

Among the 178 interviewees 45 (25.3%) were classified as hypothetical adopters and 133 (74.7%) as hypothetical non-adopters. In section 4.1, a binary logistic regression model (Adoption Model) is constructed to measure the explanatory effect of proxies for participation costs, risk, information and non-monetary considerations on adoption. With the intention to simplify the model, a second model (Reduced Adoption Model) is developed in section 4.2 by manually selecting the most significant variables that explain the largest part of adoption variance. Since participation costs did not turn out to be a significant determinant of adoption in neither of the two models, a descriptive analysis of adoption decision and participation costs follows in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

4.1 Adoption Model

The 'Adoption Model' is presented in Table 2. Beside the constant, the model is comprised of a total of 21 variables, of which eight are metric, one is a count and twelve are binomial variables. Of the twelve binomial variables, six are dummy transformed categories of multinomial variables. Thirteen variables plus the constant are significant and the model explains 50% (Cox&Snell pseudo R^2) to 74% (Nagelkerkes pseudo R^2) of the variance of the dependent variable.

Table 2 The Adoption Model

Dependent Var.	**N**	**Log-Likelihood**	**Cox&Snell R^2**	**Nagelkerkes R^2**
Adoption (1;0)	178	70.364	0.496	0.735

Independent Var.	**Coeff.B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**	**Simple[a]**
ParticipationCosts	0.006	0.003	3.500	1	0.061	1.006	*.04(+); .03/.04
PriceIndex	-0.030	0.014	4.322	1	*0.038	0.970	.71(+); .00/.00
DistCommerce	-0.083	0.042	3.895	1	*0.048	0.921	.59(+); .00/.00
Slope	1.149	0.452	6.465	1	*0.011	3.156	*.00(+); .06/.09
ProductionFocus	-1.983	1.111	3.187	1	0.074	0.138	.50(+); .00/.00
Canton(Hojancha)	-7.651	2.748	7.754	1	*0.005	0.000	.09(-); .03/.04
Canton(Nicoya)	2.310	0.938	6.066	1	*0.014	10.078	.17(+); .01/.02
Area	0.022	0.007	10.491	1	*0.001	1.022	*.00(+); .12/.18
Consumption(2)	-1.659	0.872	3.617	1	0.057	0.190	.06(-); .02/.03
Consumption(4)	-2.622	1.435	3.339	1	0.068	0.073	.92(+); .00/.00
Road(4)	-3.049	1.310	5.420	1	*0.020	0.047	.54(+); .00/.00
Off-FarmIncome	-3.247	1.867	3.022	1	0.082	0.039	*.02(-); .03/.05

%FarmIncome	-0.045	0.026	2.985	1	0.084	0.956	.08(+); .02/.03
Forest	2.943	1.496	3.869	1	*0.049	18.974	*.00(+); .12/.18
%Forest	0.038	0.020	3.724	1	*0.054	1.039	*.00(+); .16/.23
Trust(3)	3.509	1.107	10.043	1	*0.002	33.415	*.00(+); .06/.09
RiskBehavior	-2.761	1.057	6.821	1	*0.009	0.063	.14(-); .01/.02
Age	-0.066	0.032	4.196	1	*0.041	0.936	*.04(-); .03/.04
Conscience	1.382	0.792	3.043	1	0.081	3.983	.08(+); .02/.03
FearDenounce	-1.791	0.966	3.434	1	0.064	0.167	.78(-); .00/.00
NumberLandlords	-1.028	0.356	8.367	1	*0.004	0.358	.12(-); .02/.02
Constant	8.129	4.225	3.703	1	*0.054	3391.241	n.a.

[a] This column depicts the significance of the variable in a simple logistic model containing the variable as the only determinant. If the variable is significant this is depicted with an asterisk before the p-value which is followed in brackets by the sign of the coefficient in the simple regression. After the apostrophe follow the two pseudo R-square values Cox&Snell and Nagelkerkes, respectively.

Of the thirteen significant variables five are proxies for participation costs (PriceIndex, DistCommerce, Slope, CantonHojancha, CantonNicoya). Six belong to the group of risk proxies (Area, Forest, %Forest, Trust3, RiskBehavior, Age), one belongs to the group of information proxies (Road4), and one belongs to the group of other proxies (NumberLandlords). The results clearly show that adoption is not determined by participation costs (as measured here) alone. Non-monetary personal values could not be shown to play a significant role in adoption (the model does not contain a significant variable from that group). Below follows a brief discussion of the thirteen significant variables as well as the insignificant variable ‘ParticipationCosts’:

The variable ‘PriceIndex’ has, as expected, a negative coefficient and shows that adoption probability decreases as product prices increase.

‘DistCommerce’ was expected to have a positive sign because of its negative impact on opportunity costs. Yet, in the model the sign is negative. It is possible that DistCommerce has also other effects. For example, distance to commercial centers might proxy access to PES information (like DistInfoCenters). It is possible that information exchange with colleagues at commercial centers (interpersonal communication) have more significant impacts on the adoption decision than information from the so called ‘Information Centers’. The likeliness to obtain such information decreases with the distance to commercial centers, negatively impacting adoption.

The variable ‘Slope’ shows that adoption probability significantly increases with slope. Steep areas are less favorable for conventional agricultural production and therefore more apt to produce ES. Note, the measure is an average for the entire property while the adoption decision is likely only based on the most marginal and least productive areas within a farm, here those with the steepest gradients. In the case of slope the farm average turns out to be sufficient in explaining part of the adoption variation.

The two dummy variables Canton(Hojancha) and Canton(Nicoya) are both significant, the first with a negative coefficient, the second with a positive coefficient. Both were expected to bear positive signs due to lower average per hectare returns in Hojancha and Nicoya compared to those in Carrillo. But the cantons bundle several characteristics (not only per hectare returns) that can potentially influence adoption and as a whole produce an observed aggregate effect. Canton(Hojancha), for example, is significantly correlated to thirteen variables in the model, and Canton(Nicoya) is correlated to seven variables.

The variable ‘Area’ explains a large percentage of variance in the simple logit model (Pseudo R^2s: Cox&Snell 12%; Nagelkerkes 18%). With every additional hectare of land the marginal odds of adoption increase by 2.2% (Exp(B)=1.022) in the Adoption Model. The variable clearly shows that PES participation depends on the availability of land. As was already stated in Table 1, large land properties allow the landowners to experiment with new land-uses such as PES on smaller parcels without significantly impacting the current production system and without taking major risks in case of failure. Large properties also enable the landowner to enroll larger areas reducing transaction costs and thus increasing the attractiveness of adoption. Farm size also proxies the overall economic situation of a farmer which decreases the risks of adoption in case of failure. It is also likely that the owner of much land is underutilizing marginal and less favorable parts of the terrain. Their inclusion in a PES program therefore hurts less than the inclusion of highly utilized parts. PES might tip the scales in determining the land use on such marginal areas switching from underutilized agricultural use to forest conservation under PES. Given the results these effects clearly overrule the hypothesized effect that economies of scale may increase per hectare returns and thus make adoption less likely.

The existence of forest ('Forest') drastically increases adoption probability as the odds of adoption are almost nineteen times higher (Exp(B)=18.97) for someone with forest than for someone without. Among all variables though, '%Forest' (proportion of forest on total land area) explains the largest part of adoption variance in a simple logistic regression (Pseudo R^2s: Cox&Snell 16%; Nagelkerkes 23%). Its significance makes a strong statement about what type of land use is particularly interesting for landowners to enroll in PES. With every additional percent of forest on the total land area, the odds of adoption increase by 3.9% (Exp(B)=1.039) in the Adoption Model. This indicates that landowners predominantly include forest in the program. Descriptive data confirm this observation: the majority of the 3,823 ha which landowners said to be willing to enroll in PES consisted of forest (2,353 ha or 61.5%), land already under a PES contract at the time of the interview 629 ha (16.5%) and pasture fallow, so called 'Tacotales' or 'Charrales' (511 ha or 13.4%). Only 324 ha (8.5%) were pastures and 6 ha (0.2%) plantations.

If 'Trust(3)' takes the value of one an interviewee highly trusts state-run programs. In a simple logistic model this variable explains 6% (Cox&Snell R^2) to 9% (Nagelkerkes R^2) of adoption variance. A high level of trust boosts the odds of adoption by about 33 times (Exp(B)= 33.415) in the Adoption Model. The descriptive results confirm this finding and show that the hypothetical adoption rate among landowners with a high degree of trust (48.6%) is considerably higher than the adoption rate among land owners with lower degrees of trust (18.8%).

As expected, the variable 'RiskBehavior' shows that risk-averse landholders are less likely to adopt PES than others. According to the Adoption Model, the odds of adoption for risk-averse landholders are 93.7% lower (Exp(B)=0.067).

'Age' is negatively correlated with adoption. In the Adoption Model the odds of adoption decrease by 6.4% with every year of age (Exp(B)=0.936) and thus confirm the expectation that, with age, landholders become more conservative and risk-averse, both impediments to the adoption of new technologies.

The variable 'Road(4)' bears, as expected, a negative sign indicating that access to information is more difficult along bad roads. Less information increases the perceived risk of adoption and thus decreases adoption probability. Also, a poor road imposes higher transaction costs on the landowner as (s)he seeks to obtain information on PES.

The negative coefficient for 'NumberLandlords' shows that adoption probability decreases significantly (p=0.004) with the number of landlords of a property. Decision making processes may become more complex and difficult with a growing number of landowners. Although daily management is mostly in the hand of only one of the owners, fundamental decisions have to be made among all. Descriptive data supports this interpretation: Some hypothetical non-adopters stated that participation in the PES program had to be decided by the family.

'ParticipationCosts' turned out to be in the model but not among the significant variables. This could be due to suppressor effects by other proxies for participation costs (e.g. PriceIndex, Slope). But although 'ParticipationCosts' is significant in a simple regression (see column 'Simple'), it bears an unexpected positive sign which suggests problems with the computed estimates for 'ParticipationCosts'. The quality of the cost estimates was already questioned in section **Fehler! Verweisquelle konnte nicht gefunden werden.** but plausibility tests could not confirm these doubts. Standard measures to prevent survey errors had also been taken. For example, the plausibility of individual interviewee responses was controlled by cross-checking answers throughout the related questionnaires. Transfer errors from paper into digital format were minimized by comparing the final digital data sheet with the original questionnaires.

It is possible that participation costs are significant for specific groups in the sample: For example, landholders who do not trust state-run programs do not adopt independent of their participation costs while those with trust base their adoption decision on costs. The validity of this and similar assumptions was tested by using interaction terms multiplying ‘ParticipationCosts’ with variables like ‘Trust’, ‘ProductionFocus’, ‘Accessibility’, ‘Off-FarmIncome’, ‘Forest’, ‘RiskBehavior’, ‘Conscience’, ‘FearDenounce’ and ‘FearReputation’. Each variable was multiplied with three different estimates of participation costs derived from the Flow, Rent and Perception approaches giving a total of 27 interaction terms. Regressing adoption on the interaction terms, however, returned not a single significant relation.

‘ParticiaptionCosts’ is, like other variables (e.g. ‘Slope’), an average measure across all parcels of a farm. It is possible that this average is not sufficient to explain adoption. A landholder is likely to first enroll the most marginal and least productive land parcels of his property into the program. Average participation costs do not reflect the participation costs of the least productive areas and therefore may turn out to be insignificant in explaining adoption.

Comparing the performance of a variable in the simple regression (see column ‘Simple’) with its performance in the multiple regression can reveal information about a variable’s explanatory strength and relation to other independent variables. For example, the variables ‘Slope’, ‘Area’, ‘Forest’, ‘%Forest’, ‘Trust’ and ‘Age’ belong to the variables which are significant in both the simple and multiple regressions. ‘ParticipationCosts’ and ‘Off-FarmIncome’, on the other hand, are significant in simple regressions, yet lose their significance in the multiple model due to influences by other variables: ‘ParticipationCosts’ is positively correlated with ‘ProductionFocus’ ($p<0.001$) and ‘%FarmIncome’ ($p=0.029$); ‘Off-FarmIncome’ is negatively correlated with ‘ProductionFocus’ ($p=0.007$), ‘Area’ (0.009), ‘%FarmIncome’ ($p<0.001$) and ‘Forest’. A third group of variables benefit from mediator or moderator effects in the multiple regression where they are significant while they are not in the simple regression. These are ‘PriceIndex’, ‘DistCommerce’, ‘Canton(Hojancha)’, ‘Canton(Nicoya)’, ‘Road(4)’, ‘RiskBehavior’ and ‘NumberLandlords’.

4.2 Reduced Adoption Model

The variables that seem to contribute most to explaining variance are among the group of variables that are significant both in the simple and multiple regression. These are (i) ‘%Forest’ which in the simple regression has pseudo R-squares of 16% (Cox&Snell) and 23% (Nagelkerkes), (ii) ‘Area’ and (iii) ‘Forest’ which both have pseudo R-squares of 12% (Cox&Snell) and 18% (Nagelkerkes), (iv) ‘Trust(3)’ and (v) ‘Slope’ both with 6% (Cox&Snell) and 9% (Nagelkerkes), and finally, (vi) ‘Age’ (3% and 4%). If these six variables are used for a logistic regression applying a backward elimination process with likelihood ratio, ‘Slope’ and ‘Forest’ are excluded and a model results (Reduced Adoption Model) with four highly significant variables and pseudo R-squares of 30.6% (Cox&Snell) and 45.2% (Nagelkerkes) (Table 3). Forest is probably excluded from this model because of its correlation with %Forest ($p<0.001$) and Area ($p=0.032$). Slope is probably excluded because of its correlation with %Forest ($p<0.001$). The other variables in the model are not significantly correlated with each other.

Table 3 Reduced Adoption Model

Dependent Var.	N	Log-Likelihood	Cox&Snell R^2	Nagelkerkes R^2
Adoption (1;0)	178	138.383	0.306	0.452

Independent Var.	Coeff.B	S.E.	Wald	df	Sig.	Exp(B)	Simple[a]
Area	0.010	0.003	9.152	1	0.002	1.011	*.00(+); .12/.18
Age	-0.034	0.016	4.770	1	0.029	0.967	*.00(+); .03/.04
%Forest	0.044	0.009	23.093	1	<0.001	1.045	*.00(+); .16/.23
Trust(3)	2.122	0.527	16.220	1	<0.001	8.350	*.00(+); .06/.09
Constant	-1.346	0.902	2.226	1	0.136	0.260	n.a.

[a] This column depicts the significance of the variable in a simple logistic model containing the variable as the only determinant. If the variable is significant this is depicted with an asterisk before the p-value which is followed in brackets by the sign of the coefficient in the simple regression. After the apostrophe follow the two pseudo R-square values Cox&Snell and Nagelkerkes, respectively.

5 Summary and Conclusion

The paper sets out by questioning whether participation costs that are calculated from monetary flows in the past are a sufficient measure to explain a landholder's decision to enroll land in PES. Expected future costs and benefits were instead assumed to be a better measure which, however, involves considerations of risk and information in addition to monetary flows in the past. Moreover, non-monetary values such as traditions were hypothesized to influence the landholder's decision. To test the validity of these assumptions an adoption model was constructed from variables that proxy participation cost, risk, information and non-monetary values. The model explained up to 73.5% (Nagelkerkes R^2) of adoption variance. The results confirm that adoption is not determined by participation costs alone. Risk and information proxies play a significant role. Non-monetary preferences, however, could not be shown to significantly explain adoption. The results are confirmed by some of the explanations that hypothetical non-adopters gave in the field survey for rejecting PES. Participation costs had an unexpected positive effect on adoption when used as a proxy for participation costs in a simple adoption model. A detailed comparison of cost estimates with hypothetical adoption decisions could not dissolve this contradiction although a comparison with real adoption decisions tended to reveal less contradicting results. The study's main limitation that should be acknowledged is that adoption decisions are hypothetical. As Six (1975) pointed out, there can be large discrepancies between verbally expressed opinions and actually realized behavior. It is therefore possible that real adoption decisions are influenced more strongly by cost considerations than could be shown here. However, given the results at hand we conclude that approaches which derive estimates for participation costs from monetary flows in the past do not reliably determine the payment level that would be necessary to induce the landholders' PES participation. Other approaches are required to adequately consider risk factors, information access and possibly also personal preferences (which, however, could not be confirmed in this study). Inverse auction systems may be a potential alternative approach for the determination of farm level opportunity or participation costs. Their strength lies, among others, in that all adoption determinants (including risk, information and personal preferences) are potentially expressed in the landholder‘s bid.

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